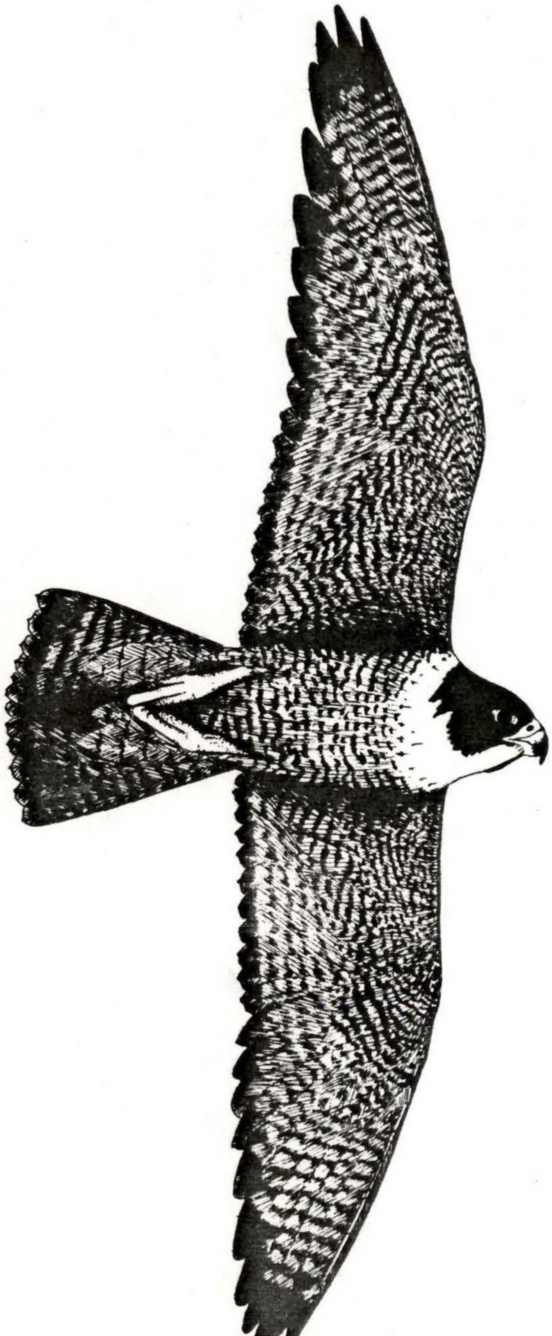
PEREGRINE FALCON MANAGEMENT ALTERNATIVES FOR ARIZONA FORESTS

David H. Ellis

Peregrine Falcon Management Alternatives for Arizona Forests



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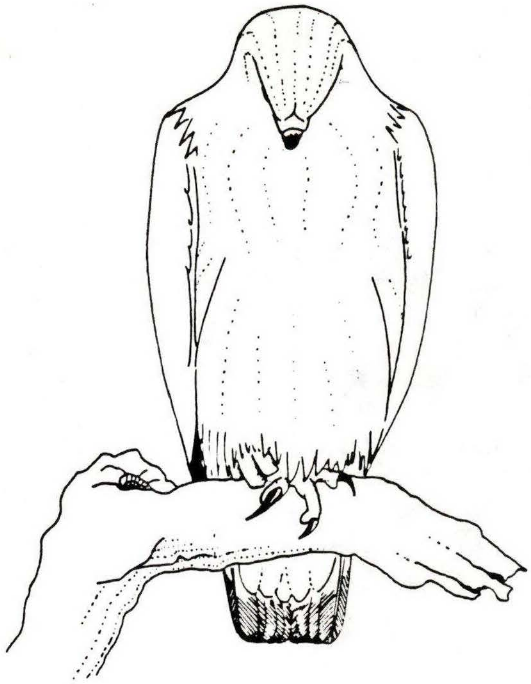

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FOR ARIZONA FORESTS

by

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PREFACE

This report provides the wildlife manager with data on the habitat preferences and management alternatives for the Arizona peregrine falcon. The early and recent breeding niche of the falcon is described. Important habitat evaluation factors are identified and collated into a tabular key for field use. Field survey methods are outlined, and important management areas delineated. Possible management alternatives for improving habitat and increasing reproductive performance are briefly discussed. With these tools (and a good deal of interpretive ingenuity) the management biologist is equipped to make management decisions to insure the falcon's survival in Arizona.

FINANCIAL CREDITS

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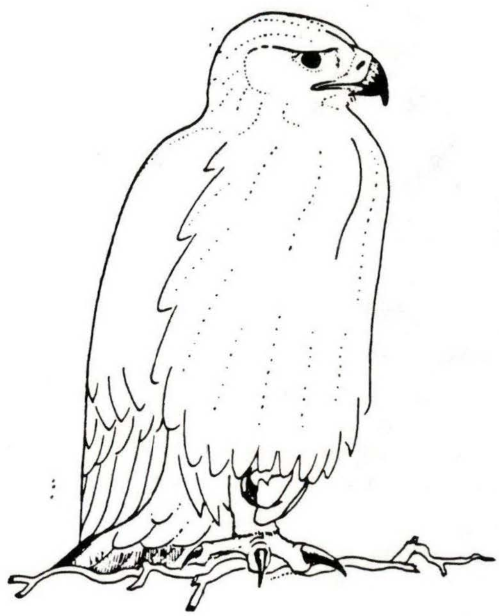

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Supporting agencies were cited earlier, but I also wish to thank Ray C. Erickson (USFWS), Teryl Grubb and David Patton (both USFS), all of whom were instrumental in arranging financial support for the study.

The following friends and colleagues provided helpful information: R. Anten, R. Balda, H. Barker, D. E. Brown, S. R. Carothers, C. R. Darling, J. Enderson, D. Fenske, R. Glinski, J. Hall, G. Huschle, R. R. Johnson, C. Kennedy, J. and S. Levy, J. T. Marshall, Jr., G. McCoard, G. Monson, A. R. Phillips, D. Prentice, J. Schnell, J. Sharber, H. Snyder, W. R. Spofford, L. Stevens, J. P. Taggart III, C. M. White, and E. O. Willis. Most significantly, Gale Monson provided many summer and winter records.

For companionship and assistance in the field, I greatly appreciate: C. (Bud) Anderson, <u>Greg Depner</u>, Steve Dobrott, Cathy Ellis, <u>Jim Fackler</u>, <u>John Goodwin, Jr.</u>, Teryl Grubb, Don Keller, Larry Stevens, and John Walker. Names of those who labored for at least one full field season are underlined. Rich Glinski generously served as pilot in the 1978 aerial surveys.

For help in preparing the final report I especially thank my draftsman-wife Cathy. Steve Loe and Bill Teigen of the Coronado National Forest provided advice and essential equipment in final report preparation.

Without the help of those listed above and the many others who have received my personal thanks, this project could not have been completed. I express to all my grateful appreciation.

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SECTION I

INTRODUCTION

The Peregrine in Arizona

No citation

In Arizona there are 34 locations where information is sufficient to conclude that peregrine falcons (*Falco peregrinus anatum*) probably or surely bred and another 34 general locations where birds likely bred nearby. summer sightings not valid Most of the old historic sites are now unoccupied (Ellis 1975), but there is a substantial nucleus of breeding adults (over 20 pairs) still remaining. Many of these are on Forest Service lands.

The peregrine falcon began to decline shortly after World War II. Within two decades the bird was nearly gone from the eastern half of the United States. By 1970 Joseph Hickey, eminent raptor biologist, 1970 predicted that the *anatum* race was "certainly" doomed. In 1971 a lone male was observed at a breeding cliff in Vermont, the last wild *anatum* peregrine seen east of the Mississippi River (W. R. Spofford, pers. comm.). Because of less intensive pesticide use, or perhaps because the falcons or their prey are less migratory, a few small populations persisted in several western states longer than in the east (Porter et. al. *In Press*, Porter et. al. *Submitted*).

Objectives

The purpose of this report is to identify management areas and provide management recommendations for the peregrine falcon on Forest Service lands in Arizona. The approach is first, to identify the traits which are common to the breeding and wintering sites in Arizona, and second, to use these common traits to identify key areas which should be managed for the falcon. The third task is to provide general and specific recommendations for management of the historic and likely falcon use sites.

Introduction to Peregrine Management

The general rationale in wildlife management is to minimize the population limiting factors and to maximize the potential for reproduction and survival. Some important factors affecting the falcon include: (1) recreational use of breeding and wintering sites, (2) pesticide applications, (3) illegal harvesting (either through shooting or taking of young), and (4) surface disturbances (logging, road building, mining, grazing, etc.). There are also many positive measures that will increase falcon use of

the Arizona forests: (1) creating additional food supplies through habitat management favoring prey species or through providing prey directly (e.g., pigeon, Columba livia, lofts near eyries), (2) creating breeding ledges on otherwise suitable cliffs, and (3) directly introducing additional falcons from captivity. The various factors are detailed in Section V, but because of its immediate bearing on the contents of this report, there follows a discussion on the critical nature of peregrine location information.

Information management: The confidential treatment of eyrie location information is essential to insure the privacy of the remaining pairs in Arizona. Current falconry regulations prohibit the taking of endangered races of the peregrine, but, as illustrated by the following excerpts, an illegal harvest continues.

Letter from N. M. Simmons, Superintendent of Fish and Wildlife Service, North West Territories, dated 27 October 1977: "Enforcement problems are of such a magnitude within this large territory that unfortunately the violator often escapes apprehension." "We have reason to suspect that peregrine falcons and gyrfalcons [Falco rusticolus] are taken out of the Territories illegally each year." "....our prosecution rate for raptorial birds is very low."

Letter from LeRoy W. Sowl for Gordon W. Watson, Area Director, Fish and Wildlife Service, Anchorage, Alaska, dated 25 October 1977: "....the biggest [raptor] problem is people coming to Alaska attempting to capture Peregrines and Gyrfalcons for falconry or sale."

Frank S. Todd, Curator of Birds, Los Angeles Zoo, Los Angeles Times, 8 November 1974: "During eight years at the Los Angeles Zoo I was never able to maintain a peregrine without having it stolen. On one occasion wardens brought a pair of peregrines and a gyrfalcon they had confiscated. They were stolen in two days."

Philip Glasier, Director, The Hawk Trust, England, 1972 in Captive Breeding of Diurnal Birds of Prey 1(3): "Peregrines on loan to The Hawk Trust made a scrape on a ledge and looked very much like laying but were stolen together with another pair. This theft not only put back our hopes of breeding peregrines but meant that we had to spend a considerable amount of money in various alarm and identity systems."

The release of eyrie locations either through too freely using this information within agencies or through publication (even in scientific reports) is likely to result in increased harrassment, not only from falconers, but also by photographers, the curious, and even agency employees anxious to see these rare and beautiful birds. Because of this danger the Wilson Ornithological Society, the American Ornithologist's Union, and the Southwest Hawk Watch have adopted resolutions recommending the confidential treatment of information regarding the breeding sites of vulnerable raptors.

The Approach

Several methods were used in gathering information for this report. An extensive literature and personal contact survey was begun in 1974 and continued. Beginning in 1975 all reported breeding sites were visited (many of them annually) to determine occupancy and to gather data on over 25 aspects of the natural features of the site. Using the traits which were common to many or all sites, in 1976 and after we began to systematically search for new pairs. With the descriptive data from the newly found sites, enough information was available to develop a key for evaluating Forest Service lands. In 1978 all Forest Service lands in Arizona were systematically flown and ranked according to the descriptive key. After being ranked, over 100 sites were visited on the ground. The results of these aerial and ground surveys provide the basis for the management guidelines that follow.

likely areas - not sites

SECTION II

CRITERIA FOR BREEDING HABITAT EVALUATIONS

Rational

However unfortunate for the bird, the artificial reduction of peregrine falcons in recent decades provides us with a unique opportunity to study the habitat preferences of the bird. If it is assumed that, with two decades of population depression, the sites which remain occupied are those most favored by the falcon, then by comparing the recent sites (post 1969) with the early sites (pre 1970), we should be able to identify directional trends in some descriptive parameters (i.e., are the birds now very near water, only on tall cliffs, etc.).

This approach is an extension of the "ecological magnet" concept proposed by Hickey (1942). With due regard to Bond's (1946) and Cade's (1960) disputing statements based on their records for the western United States and Alaska, Hickey and Anderson (1969) reiterated the belief that favored sites did have certain common traits. (Rice, 1969, provides additional supporting evidence.) For this report, I quantified many habitat parameters at Arizona eyries in an effort to identify common traits. Presumably, if the site description parameters are carefully chosen, we will not only have a good measure of the falcon's habitat preferences, but we should also be able, using those factors showing the strongest trends, to develop a mathematical model for use in evaluating the suitability of areas with no history of falcon use.

Methods

The first phase of the survey began in 1974. A search of the published literature revealed many references to peregrine observations but very few references to breeding. Only two of the published breeding locations were on Forest Service lands (Mearns 1890, Brandt 1951, and Ligon and Balda 1968). A search of agency files resulted in a few more records, but more valuable was a personal contacts survey from 1974 to the present. Nearly 100 persons suspected of having knowledge of the peregrine in Arizona were contacted. Most were given telephone or in-person interviews. Where personal interviews were impractical (i.e., for persons living abroad), inquiries were mailed. The importance of the personal contact survey is apparent from Table 1. How many?

All of the sites accounted in Table 1, including those located in 1978, have been visited from the ground. At each site data were

what is the purpose of the table? Duplication of observations - categories should be exclusive -

TABLE 1

SOURCES FOR THIRTY-FOUR PEREGRINE FALCON BREEDING RECORDS FOR ARIZONA[1,2]

Site Classification[3]	Number Found by Each Method			
	Literature	Agency Files	Personal Contacts	Fieldwork
Known	4	0	10	9
Probable	1	5	10	3
TOTAL	5	5	20	12

[1]Sites from more than one type of source are included in the table more than once, hence an overall total of 42.

[2]Records are available for 50 additional summering sites where information is insufficient to conclude breeding.

[3]Sites were classified as follows:

Known: locations where eggs, nestlings, or recently fledged young have been reported by a competent, reliable observer.

Probable: locations where during the breeding season competent, reliable observers reported at least: (1) two observations of a pair of adults attending a specific cliff, or (2) one observation of an adult calling and stooping at an intruding human near a suitable nesting site.

gathered on as many as possible of the habitat parameters listed ~~in~~ Table 2. All measurements were rounded to significant figures. Considering the difficulty in obtaining exact measurements a maximum of ten percent error was allowed (i.e., a 50 m cliff was measured or approximated to the nearest 5 m while a 200 m cliff was approximated to at least the nearest 20 m if it could not be measured directly).

Developing a Model for Habitat Evaluations

In Arizona the peregrine breeds over a tremendous range of environmental conditions. Birds nested in rainfall zones varying from less than 6 inches/year to over 30 inches/year. An elevation range from less than 500 feet to nearly 9000 feet was used. Breeding sites varied from short bluffs in relatively flat terrain to towering walls of rugged mountain canyons.

low

The object in the following discussion is to sort, from more than 25 descriptive parameters (Table 2), those which are most useful in describing the habitat preferences of the peregrine and most useful in developing a habitat evaluation model. The purpose in what follows is not to describe the typical eyrie but rather to identify the range of suitability for each parameter, therefore, the data will be handled with due emphasis on the extreme values. For purposes of this report, history is divided somewhat arbitrarily at 1 January 1970. "Early sites" are those not known to have breeding birds after 1969. "Recent sites" are those with a history of occupancy by a pair of birds after 1969. The date was chosen for two reasons. First, the records suggest that the bird had declined enough by 1970 to support the assumption that marginal sites were no longer occupied. Second, this division provides for a sufficient number of sites in each temporal group to allow their comparison (i.e., 20 recent sites vs. 14 early sites).

can't talk of preference w/o knowing availability

Elevation: In Figure 1 the trends in elevation are presented for early and recent sites. There is no elevational preference shown in the early sites, and the peak around 5,000 to 7,000 feet in the recent data is perhaps better explained by rainfall and plant communities than by elevation. However, the lack of high altitude breeding sites in either temporal category likely reflects an avoidance of the zone over 9,000 feet. As stated in the Recovery Plan (U.S. Fish and Wildlife Service 1978: 16) "....nesting above 8,500 feet is rare." The most elevated site in Arizona is at 8,700 feet.

Topographic relief: Total topographic relief was measured as the vertical distance between the ~~high and~~ low points in a r=2 mi circle centered on the breeding cliff. Prominance was measured as the vertical distance from cliff rim to low point in the same circle.

In Figure 2, many sites, both early and recent, are not greatly elevated above the lowlands. Nine recent sites are less than 1500 feet above the valley floor. Apparently prominance (Figure 2) is a less

w/in 2 mi r.
lowland is not the word.

why choose 9 and why 1500'

TABLE 2

BREEDING SITE DESCRIPTION PARAMETERS

I. Topography
   A. Elevation[1]
      1. at cliff rim
      2. at high point (r=2 mi)
      3. at low point (r=2 mi)
      4. total topographic relief (No. 2 minus No. 3)
   B. Cliff
      1. Height[1,2]
      2. Verticality[2]
      3. Extent of comparable cliff (r=2 mi and r=0.6 mi)[1]
      4. Directional exposure[1]
      5. Was tallest cliff used (r=2 mi)?
      6. Was most elevated cliff (of comparable height) used (r=2 mi)?
II. Vegetation[3]
   A. Community at cliff base, at cliff top, at nearest water
   B. Predominant community in circle (r=2 mi).
III. Hydrology
   A. Annual precipitation[4]
   B. Type, extent, and distance of nearest surface water[5]
   C. Type, extent, and distance of alternate source[5]
IV. Prey
   A. Probable hunting areas
   B. Most probable prey
      1. species
      2. abundance
      3. proximity
V. Administration (or ownership) of site
   A. Cliff
   B. Near environs

[1]Approximated from USGS topographic maps compared with aerial and terrestrial oblique photographs

[2]Measured with pocket-transit and compared with approximations of the site from 1.

[3]Vegetative communities after Brown 1973.

[4]Precipitation zones from U.S. Weather Bureau maps for Arizona.

[5]Important permanent water sources were identified from Brown et. al. 1977.

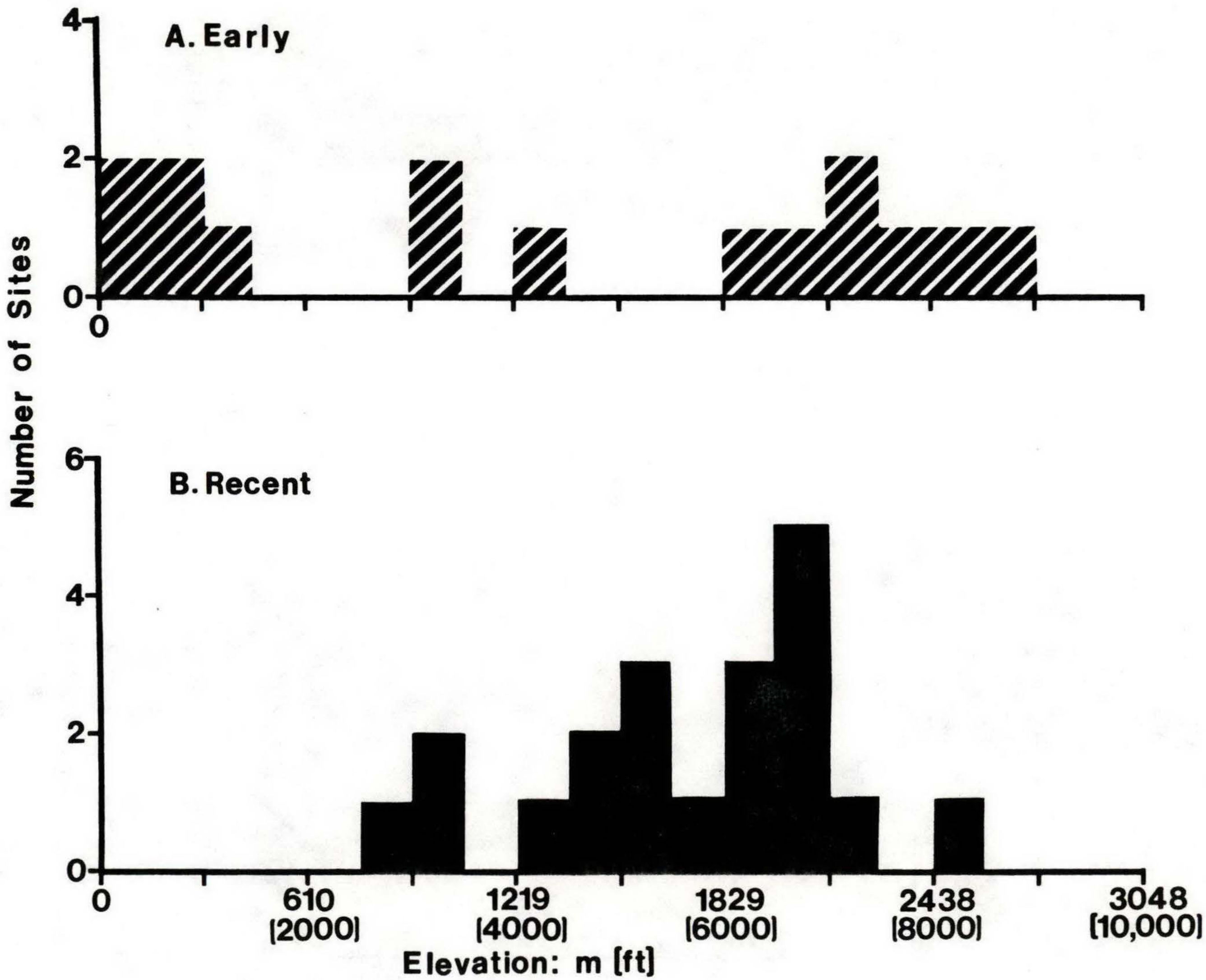


Figure 1. Elevation at cliff rim. For A, N=15. For B, N=20.

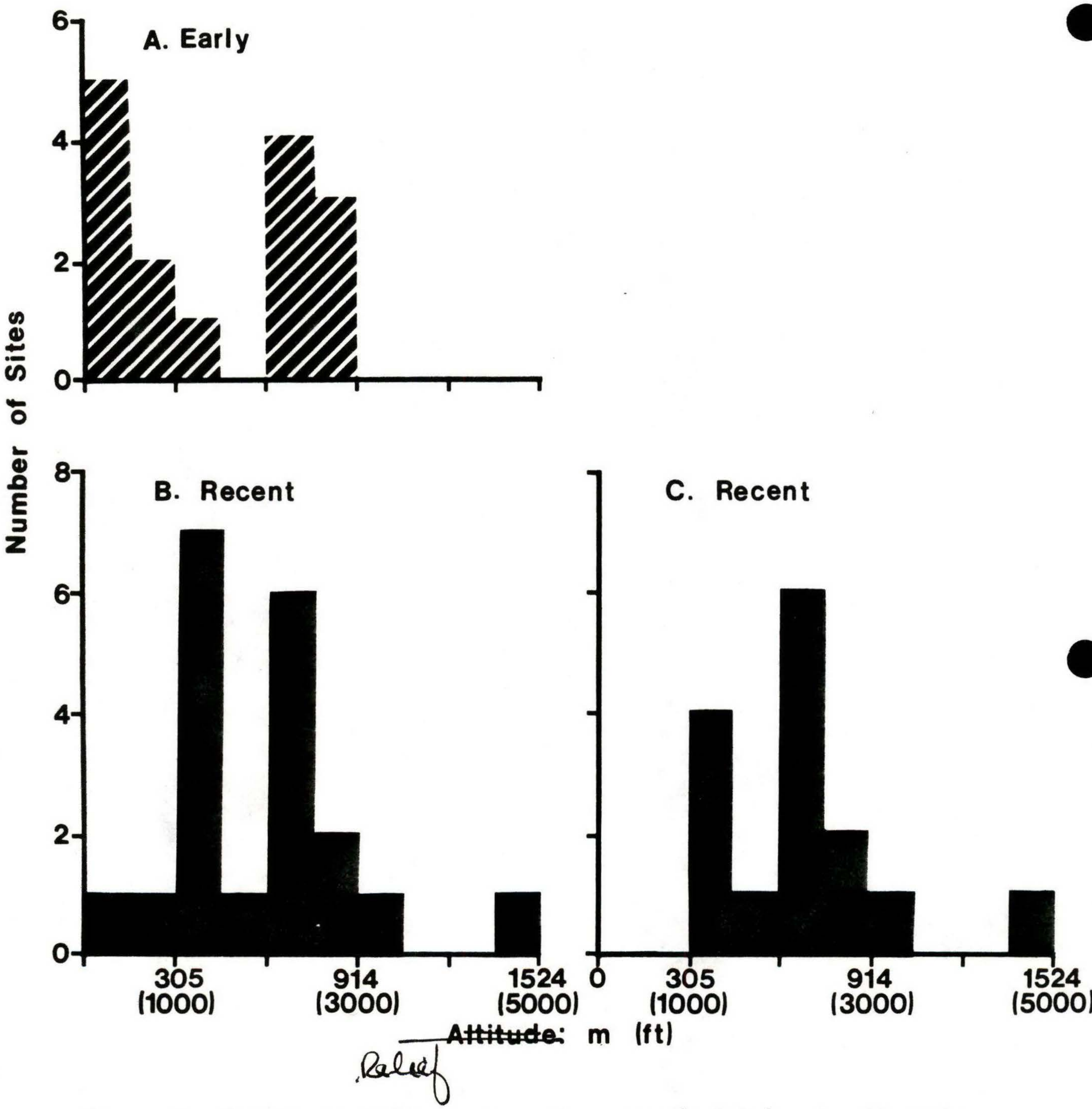


Figure 2. Height of cliff rim above low point (r=3 km). A, all early sites (N=15). B, all recent sites (N=20). C, those recent sites over 0.5 km from extensive permanent water (N=15).

Leave perm. water out of this comparison.

distinct ~~diagnostic character~~ than total topographic relief (Figure 3).

All sites with less than 1000 feet prominance and less than 2000 feet total relief are closely associated with major permanent streams or rivers. At riparian sites it may be advantageous to the bird to be near the prey supply which is concentrated low over the water or low over a riparian forest canopy. An alternate hypothesis is that the birds nesting low over water achieve some thermal (cooling) or wind current advantage. At any rate two trends are apparent in the data (Figure 2). Near major water sources birds can be expected to regularly nest low (within 1000 vertical feet of the low point) whereas far from water the falcons regularly nest higher. A recent trend toward high total topographic relief (1500 feet minimum) is apparent in Figure 3B.

No different from

For only 5 sites!

Contradicted by Fig 2.

Cliff height: In measuring cliff height, the observer must decide somewhat arbitrarily where the cliff starts and ends. For this report I considered the cliff base to be the highest point achievable by walking. The cliff rim was the low point achieved by walking. Many cliffs are divided into layers by broad ledges. Where the ledges could be obtained by walking the topographic feature was considered two cliffs (one of which was measured for height). For example, the shortest recently active cliff is 140 feet, but this site actually consists of a series of cliffs in sum hundreds of feet tall. Because the ledges dividing the series are approachable without climbing, 140 feet is used as the cliff height. If the ledge could only be reached by climbing, the cliff segments above and below the ledge were counted together.

The cliff height data (Figure 4) are very different for early and recent sites. Recent cliffs average fully twice as tall. Excepting two sites which actually consisted of segments of taller cliffs, all recent sites were over 300 feet tall. Most (9 of 14) early sites are cliffs less than 300 feet tall, with low extremes of 60', 50', 75' and 75'. Cliff height emerges ~~surfaces~~ from the analysis as a strong measure separating marginal from fully suitable sites. ~~Emerges from the~~

Cliff verticality: Of 33 cliffs considered in the analysis, 25 were vertical (80-90°) and 8 (4 recent and 4 early) were non-vertical (70-80°). At all sites the segment of the cliff immediately above and below the eyrie was vertical or overhung. Some sites were so severely overhung that they were entered by first rappelling to the right or left of the eyrie, second traversing under the overhang, and third rappelling down into the eyrie. The three types of non-vertical cliffs encountered in the study are illustrated in Figure 5.

Extent of suitable cliff: The recent vs. early ~~trends~~ ? ends in this parameter are very different. Two early sites lacked tall cliffs altogether (Figure 6). With one exception, all recent sites have extensive or most extensive suitable cliffs (Figure 7).

The one recent site with tall but non-extensive cliffs illustrates the importance of using a combination of factors in evaluating the suitability

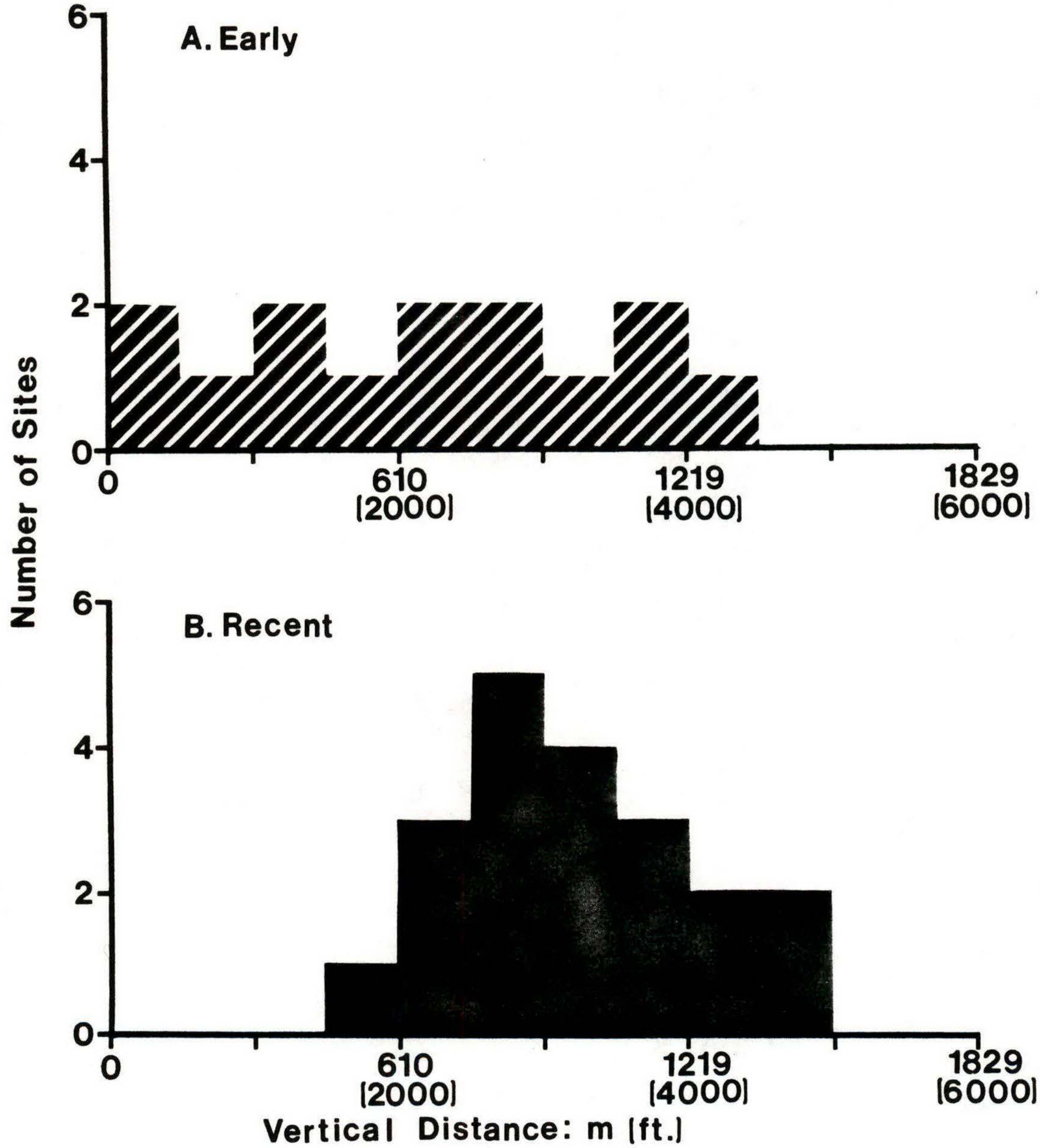


Figure 3. Total topographic relief (r=3 km). For A, N=14. For B, N=20.

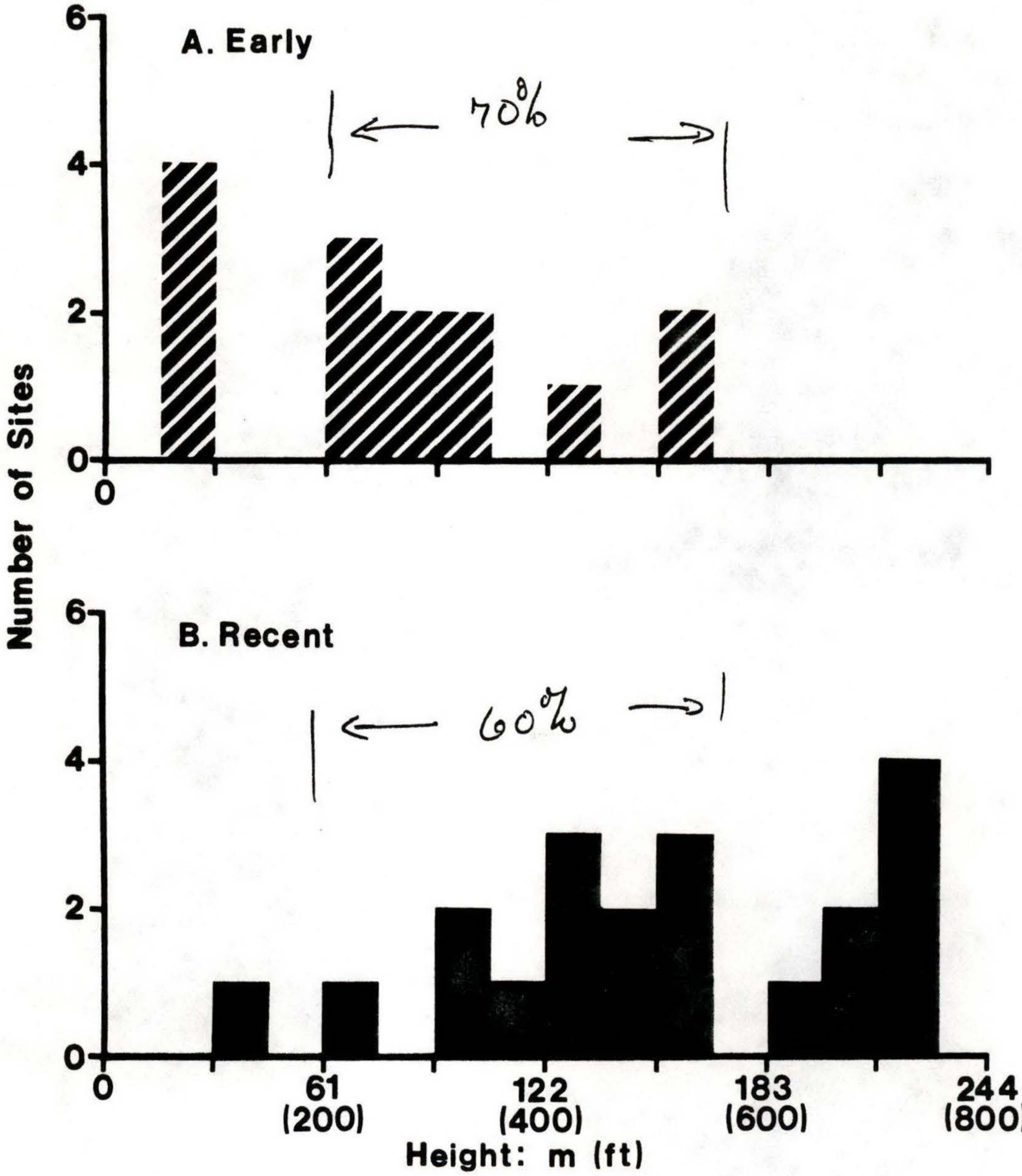


Figure 4. Cliff height. For A, N=14. For B, N=20.

Not different!

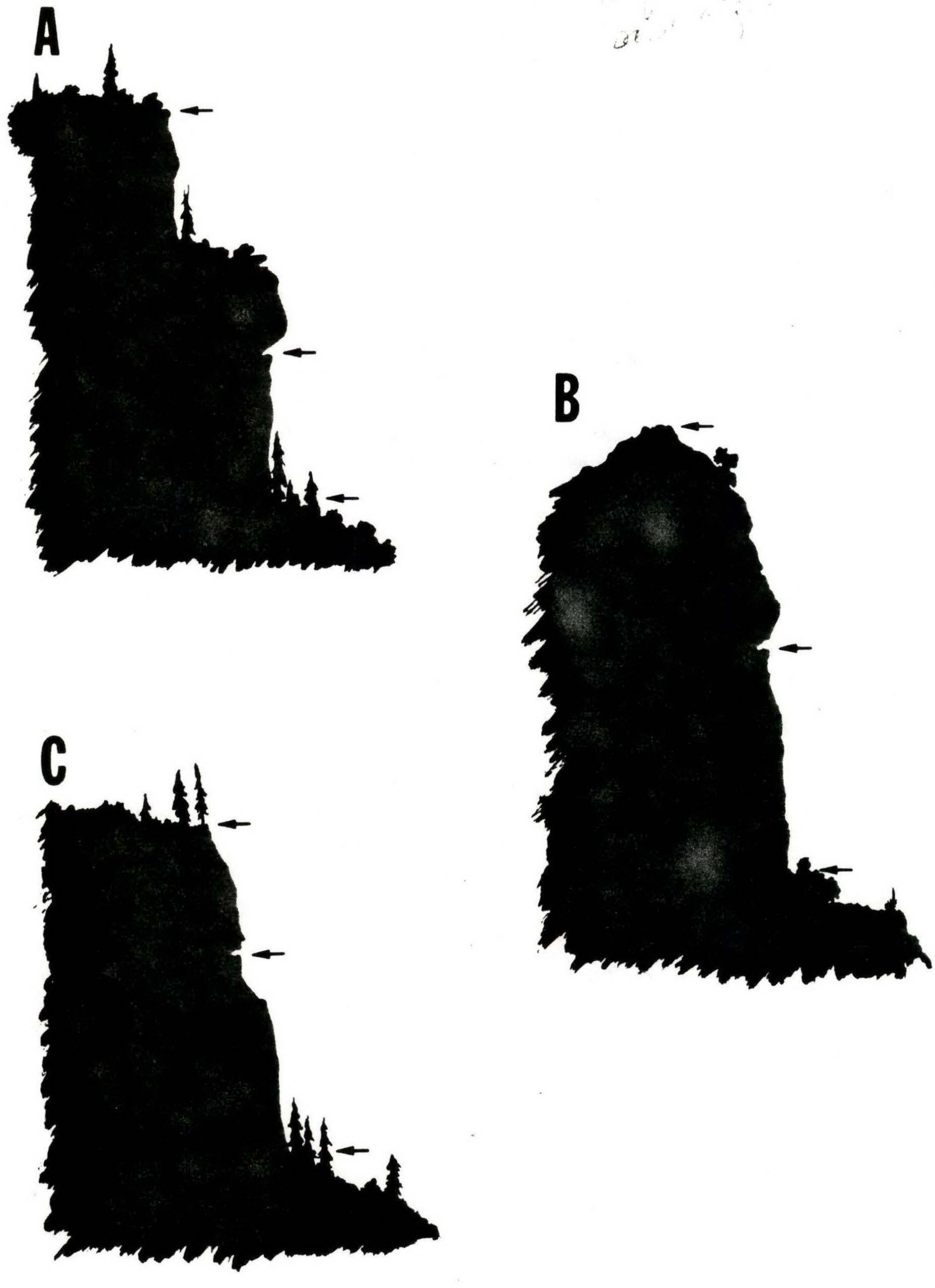


Figure 5. Cross-sections through three types of non-vertical eyrie cliffs. A, Cliffs lying in segments with non-accessible ledges. B, Cliffs with inaccessible sloping tops (e.g., pinnacles). C, Sloping cliffs with a vertical segment. Rim, base and eyrie are at designated levels in each drawing.

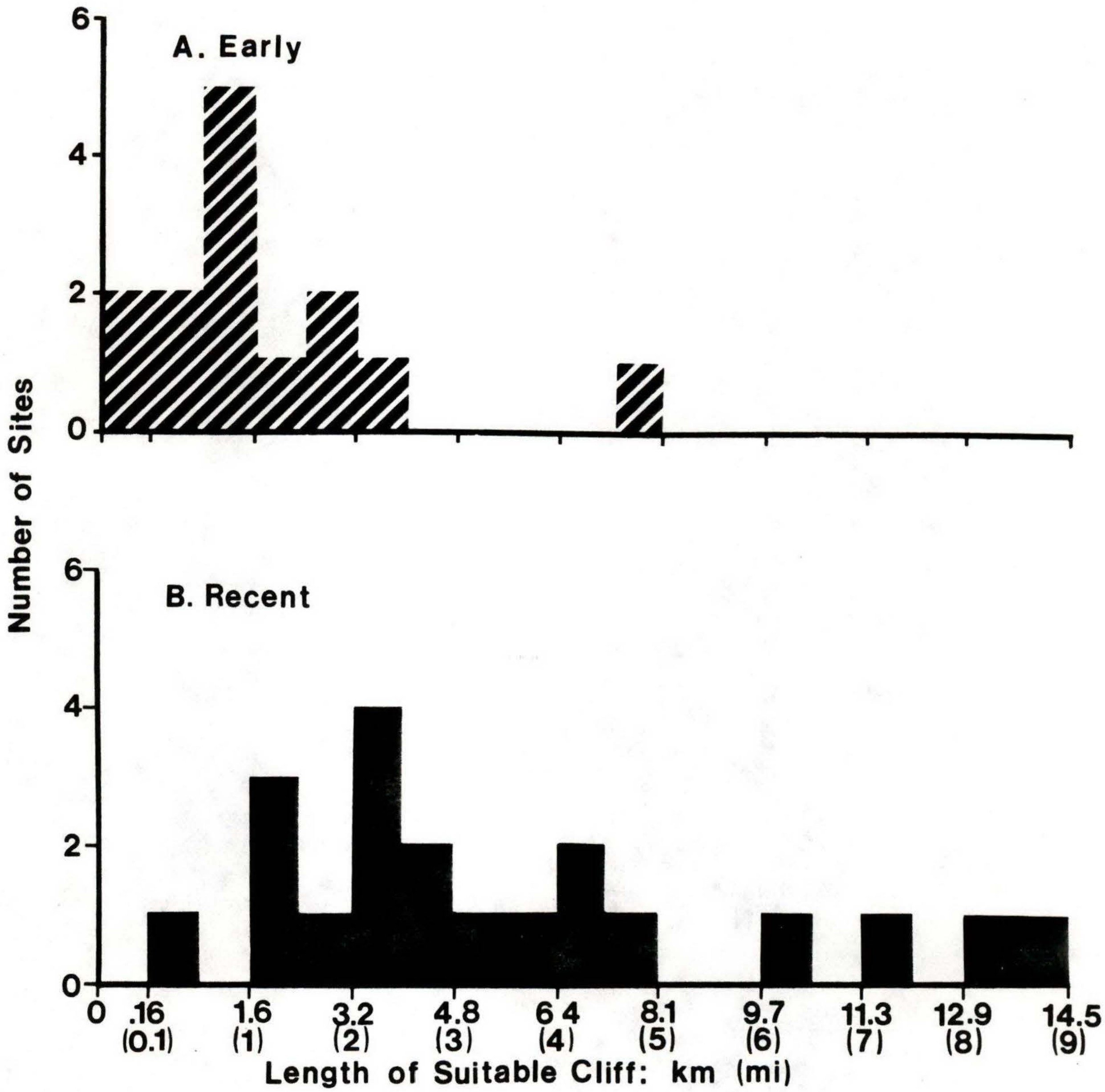


Figure 6. Extent of suitable cliff (r=1 km). For A, N=14. For B, N=20. Suitable cliffs are defined as those either ≥ 200' (61 m) or ≥ 125' (38 m) if lying in a series of layers which total ≥ 250' (76 m).

Height means nothing - its the pattern

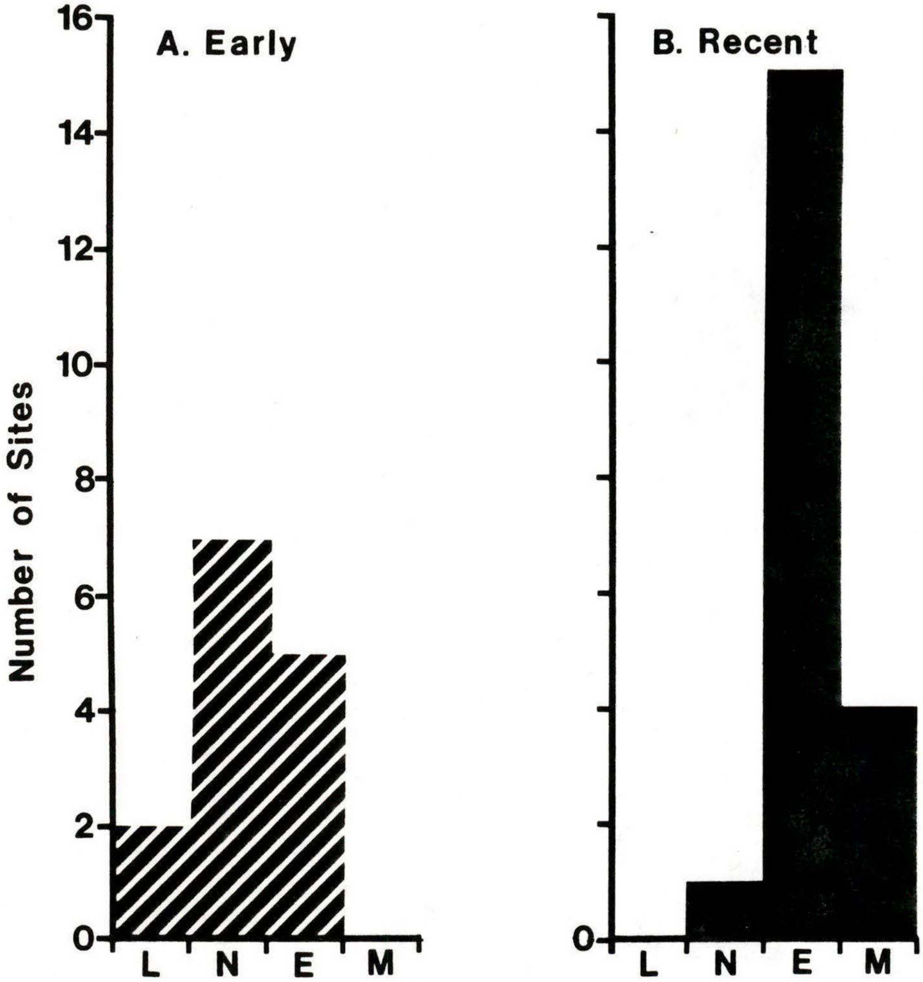


Figure 7. Extent of suitable cliff by classes. (For A, N=14. For B, N=20.) Class abbreviations are: Lacking (L): without suitable cliffs. Non-extensive (N): sites with 0.1-0.90 mi (0.2-1.4 km) of suitable cliffs. Extensive (E): sites with 1.0-4.9 mi (1.6-7.9 km) of suitable cliffs. Most extensive (M): sites with at least 5.0 mi (8.0 km) of suitable cliffs.

of a site. Because the site, when located from the air, appeared exceptionally suitable for topographic relief, availability of water, and cliff height, it was ranked suitable even though there were very few available cliffs. Ground inspection revealed a pair of birds which fledged two young.

here goals? more best evidence of preference

Directional exposure of breeding cliffs: This parameter is not the directional exposure of the eyrie ledge (considered in Section V) but rather the general direction which the breeding cliff faces. Sites where the eyrie location is not sufficiently known were not treated here. Sites on multifaced non-extensive cliffs are also deleted. For two sites data for two separate breeding cliffs are presented.

Porter and White (1973: 20) found that the peregrines in Utah most often nested on north and east facing cliffs, presumably for thermal reasons. The data for Arizona show high utilization of north and west facing cliffs, but little use of south facing cliffs (Figure 8). When the pooled data are compared (Figure 9) it is apparent that peregrines can nest on cliffs facing any direction even in the warm climate of the southwestern United States.

After visiting several sites which face south and west, it is apparent that the structure and placement of the eyrie is often more important in determining the degree of insolation than the orientation of the cliff. For example, at the two sites which face south-southeast (and which would likely be insolated most of the day) overhung ledges provide continual shade for the nestlings. At another site, a wall across the canyon shades the west facing eyrie after about 1500 hrs. Some breeding ledges are strewn with boulders and vegetation which also provide shade. Because of the lack of clear direction preferences, cliff orientation is of little use in evaluating the suitability of potential breeding sites.

Vegetation at breeding sites: Breeding sites (early and recent) occur over a range of vegetation types from montane conifer forest to Mohave and Sonoran desert (plant communities used in analysis were from Brown 1973). Because of the difficulty in assigning numerical scores to vegetation types, no treatment is presented here. At any rate, vegetation is largely a reflection of rainfall patterns which can be treated quantitatively.

Wrong! Involves slope & soil

Annual precipitation at the breeding sites: Most recent sites are in wetter rainfall belts than the early sites, but two recent sites are in the 5-10 inch zone (Figure 10). Here again a two factor explanation is helpful: all recently active sites occur either very near extensive permanent surface water or in rainfall zones of not less than 15 inches/year or both. Four of six early sites in the 5-10 inch rainfall group are very near extensive permanent surface water.

Proximity to permanent surface water: Even the dryest areas have standing and running water occasionally. Artificial empoundments, natural potholes, and seeps provide permanent or near permanent water sources for wildlife and domestic livestock over most of Arizona. Because of the

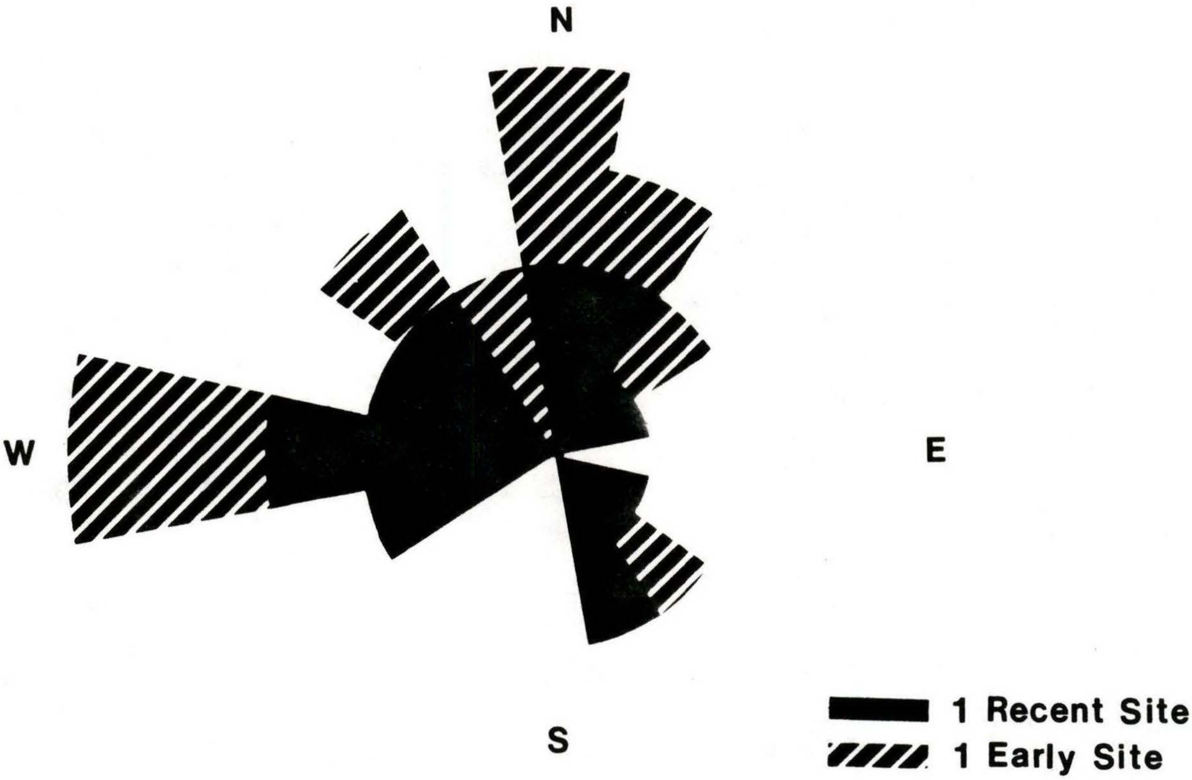


Figure 8. Directional exposure of breeding cliffs in Arizona (N=29).

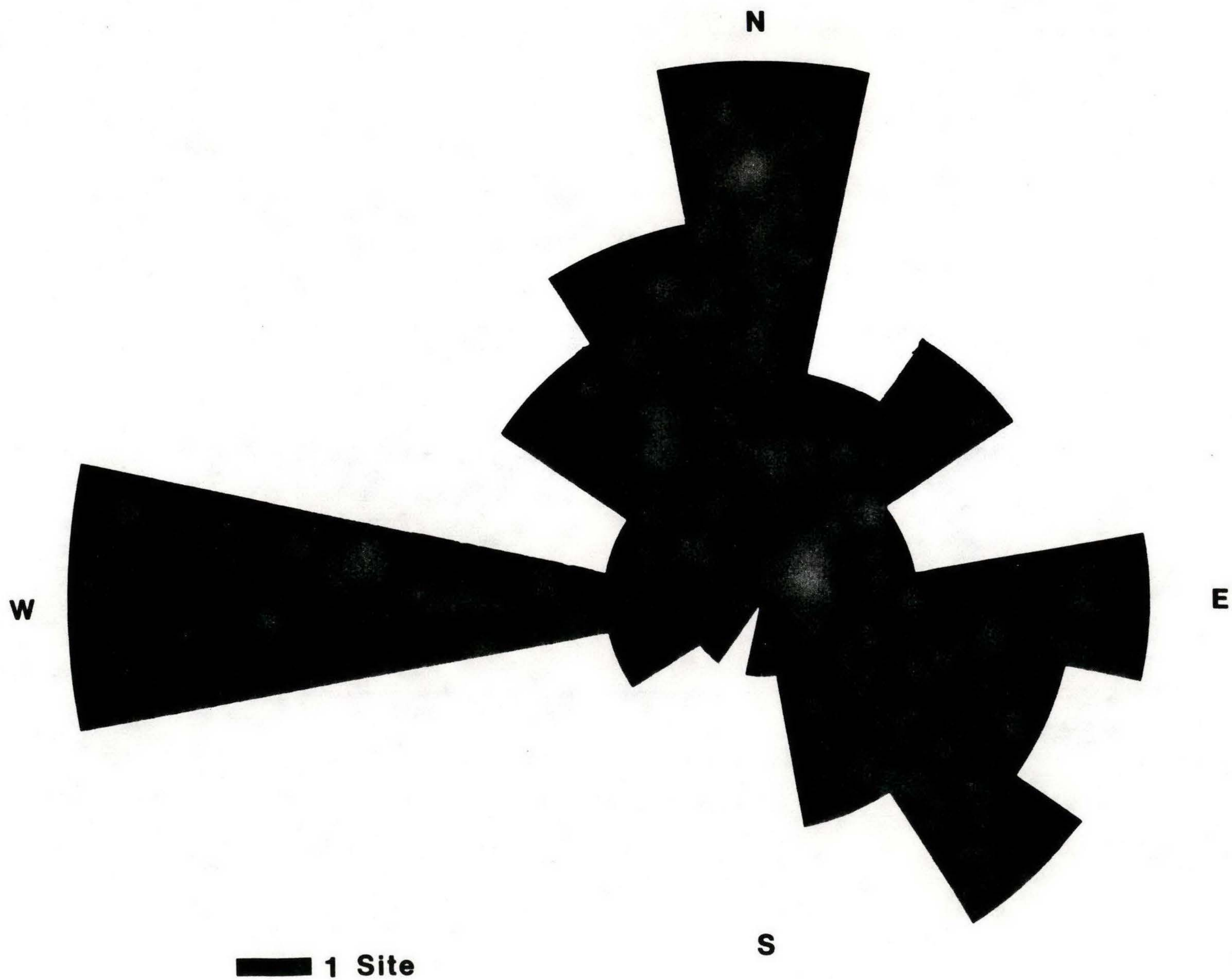


Figure 9. Directional exposure of breeding cliffs in Utah and Arizona (N=57). Utah data from Porter and White (1973).

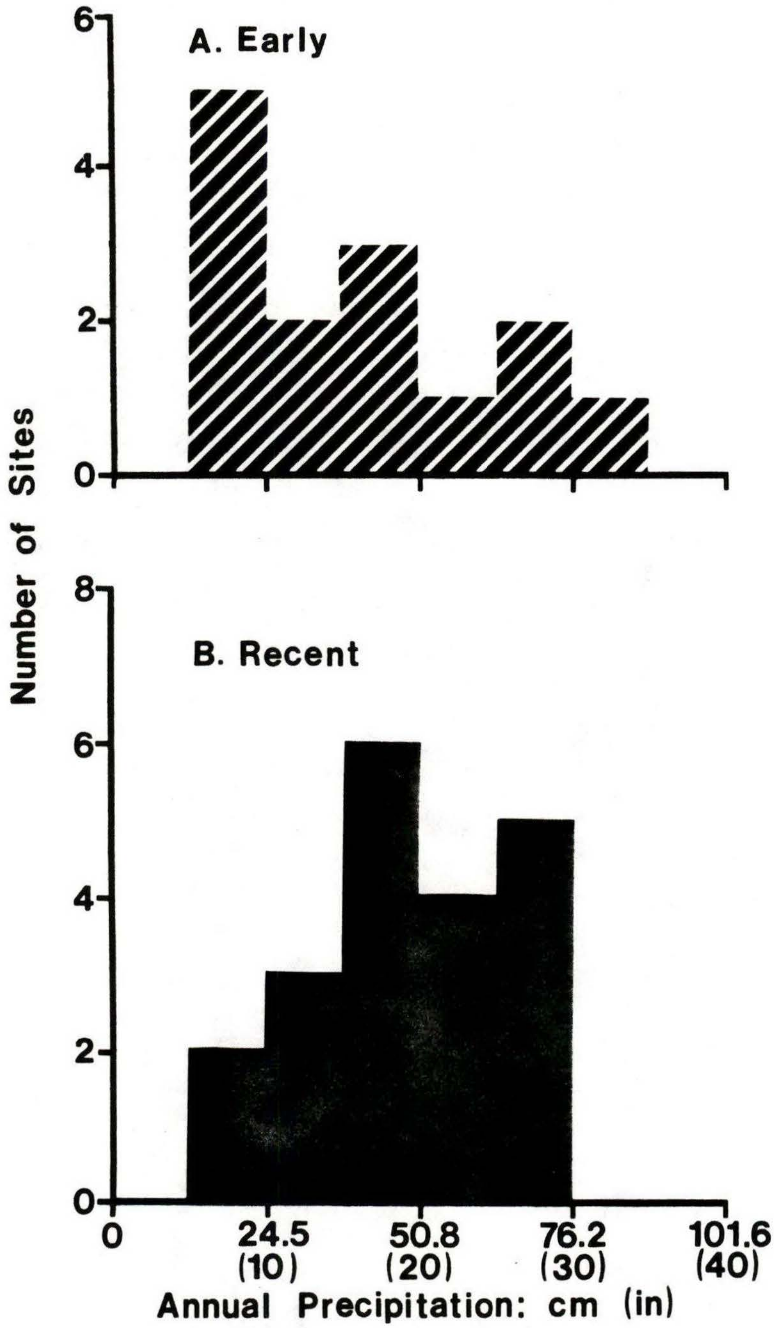


Figure 10. Annual precipitation at breeding sites. Data from U.S. Weather Bureau. For A, N=14, For B, N=20.

difficulty in determining positively that water is both present and permanent, the water sources used in this treatment are those identified by Brown et. al. (1977) plus a few artificial empoundments of known permanency.

The importance of nearby surface water is illustrated in Figure 11. All of the early and recent sites which are great distances from water have near-permanent sources nearby. One recent site, for example, is just above a near-permanent stream and overlooks a reservoir which is wet throughout the breeding season, however, the nearest water of known permanency is 12.0 miles--hence the site is reported as far from permanent water.

For the sites near permanent water, the source types are reported in Figure 12. Rivers, lakes, and streams are the most important sources. The recent site near a natural pond is also within 6 miles of a large river.

Other site description parameters: Data were gathered on several factors besides those in the preceeding discussion (Table 2). However, those factors already presented are sufficient to identify habitat utilization trends. It would be useful to present data on prey availability but the wide ranging nature of the falcon makes this factor most difficult to quantify.

Selecting key factors for habitat evaluation: The object in the following discussion is to choose from the factors which have just been presented those which are most useful in describing the preferred breeding niche of the peregrine falcon and, as a result, most useful in evaluating potential habitat. Two types of key factors surface--those which are common to all breeding sites, and those for which trends are very different for early and recent sites.

Traits which are common to all sites include:

1. Elevation less than 9000 feet.
2. Cliff height $\geq$50 feet.
3. All cliffs near vertical ($\geq 70^{\circ}$ from horizontal) with a vertical segment.
4. All sites within 6 miles of permanent streams, rivers or ponds, or associated with mountain ranges which have large ephemeral streams.

Minimum values for recent sites include:

1. Prominence at least 1000 feet unless within 1 km of extensive permanent water (r=2 mi).
2. Topographic relief $\geq$1500 feet (r=2 mi).
3. Cliff height either: $\geq$200 feet, or lying in a series with one layer at least 125 feet tall and the total series at least 250 feet tall.
4. Suitable cliffs at least 0.1 mile in extent (r=.6 mi).

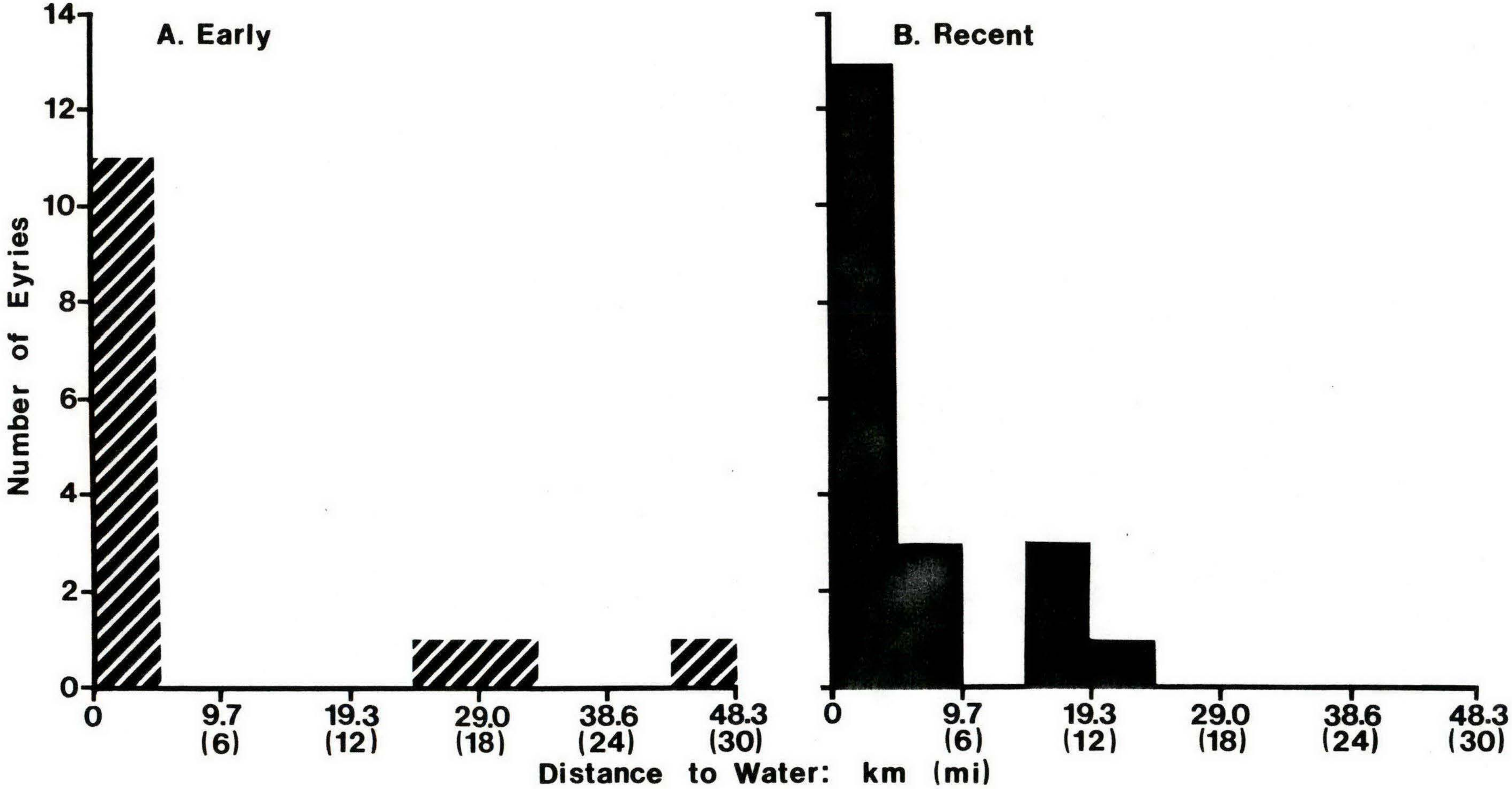


Figure 11. Distance from breeding sites to permanent surface water. For A, N=14. For B, N=20.

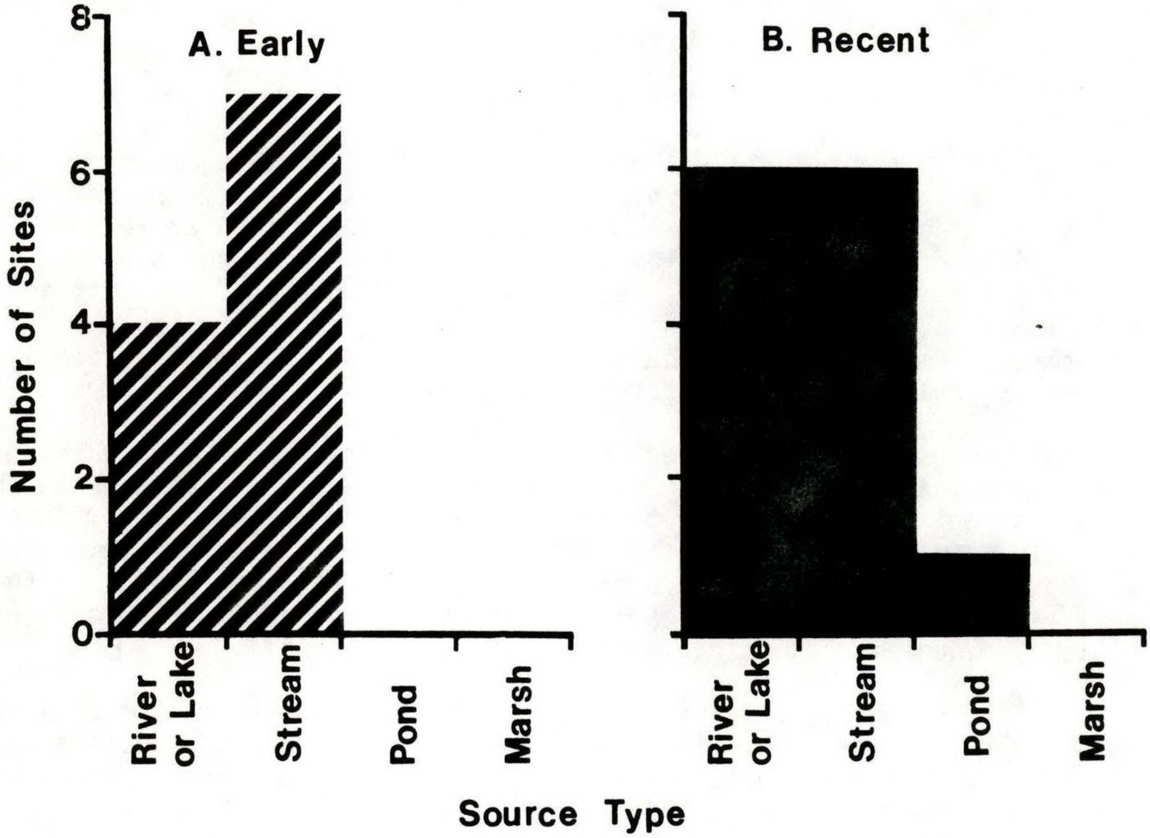


Figure 12. Source types of permanent water near (< 5 km) breeding sites.

statements, there are not comparisons

Tendencies which surface from the comparison of early and recent sites include:

Look at Fig 3

1. Most recent (hence most suitable) sites are between 4500 feet and 7500 feet elevation.
2. Most recent sites have at least 2000 feet of total topographic relief (r=2 mi).
3. Most recent breeding cliffs exceed 300 feet tall.
4. Recent sites tend to have at least one mile of suitable cliff (r=.6 mi).
5. Most sites (early and recent) are within 3 miles of permanent streams or rivers.

Mathematical collation of a series of unequal parameters no matter how carefully performed unavoidably introduces biases. Several quantitative comparisons were attempted using the key traits identified above. All resulted in a great amount of overlap between the scores for the two temporal groups. The data were manipulated to reduce this overlap. The method which was finally accepted yields the least overlap and is a relatively simple treatment, however, it unavoidably employs a series of arbitrary decisions concerning relative weights of the parameters.

The four factors used in the treatment are the traits showing the greatest potential for defining the breeding niche of the falcon. In the treatment an attempt was made to avoid penalizing sites which provide a sufficiency of a certain trait merely because other sites show this trait in excess. For example, if 2.0 miles of suitable cliff is enough to fully satisfy the preferences of the falcons, then a 2.0 mile site should be assigned a score equal to a site with 8.0 miles of cliff.

The scoring codes are talled in Figure 13. The site scores are illustrated in Figure 14. The zone of overlap (5.5 to 6.5) contains those recent sites which are deficient in some parameter and those early sites which are likely candidates for reoccupancy.

In Figure 14 four terms are introduced for site evaluations. The "most suitable" sites have no obvious deficiencies. Sites which rank in this category and which meet the criteria listed in the text above should be given highest priority in falcon management even when they do not have birds. "Suitable" sites can regularly be expected to harbor birds. "Marginal" sites should regularly be occupied once populations recover. "Sub-marginal" sites near extensive water providing prey concentrations will occasionally be occupied once populations recover. Sub-marginal sites far from water will seldom be occupied and are of little importance in falcon management.

Using the site scoring system presented in Figures 13 and 14, and other clearly directional trends listed above, a habitat evaluation key was prepared for field use (Figure 15). This device, requiring minimal reference to surface water and topographic maps, was used to score the Forest Service lands in Arizona. The usefulness of this device can be measured by its

Parameter (unit)	Terms Value Classes Scores			
Total Topographic Relief (ft)[1]	Low 0-999 0	 1000-1499 .2	Moderate 1500-1999 1.0	High 2000+ 2.0
Cliff Height A (ft)[2]	Short 0-124 0	Tall 125-199 1.0	Very Tall 200+ 2.0	
Cliff Height B (ft)[3]	Short 0-199 0	Tall 200-299 1.0	Very Tall 300+ 2.0	
Cliff Extent (mi)[4]	Lacking 0 0	Non-Extensive 0.1-0.9 1.0	Extensive 1-1.9 1.6	Very Extensive 2+ 2.0
Distance to Permanent Water (mi)	Very Near 0-2.9 1.0	Near 3.0-5.9 0.5	Far 6.0+ 0.5	

Figure 13. Site scoring code. [1]R=2 mi. [2]Cliffs composed of layers totaling $\geq$ 250 ft with one layer $\geq$ 125 ft. [3]Cliffs not in accessible layers. [4]R=0.6 mi.

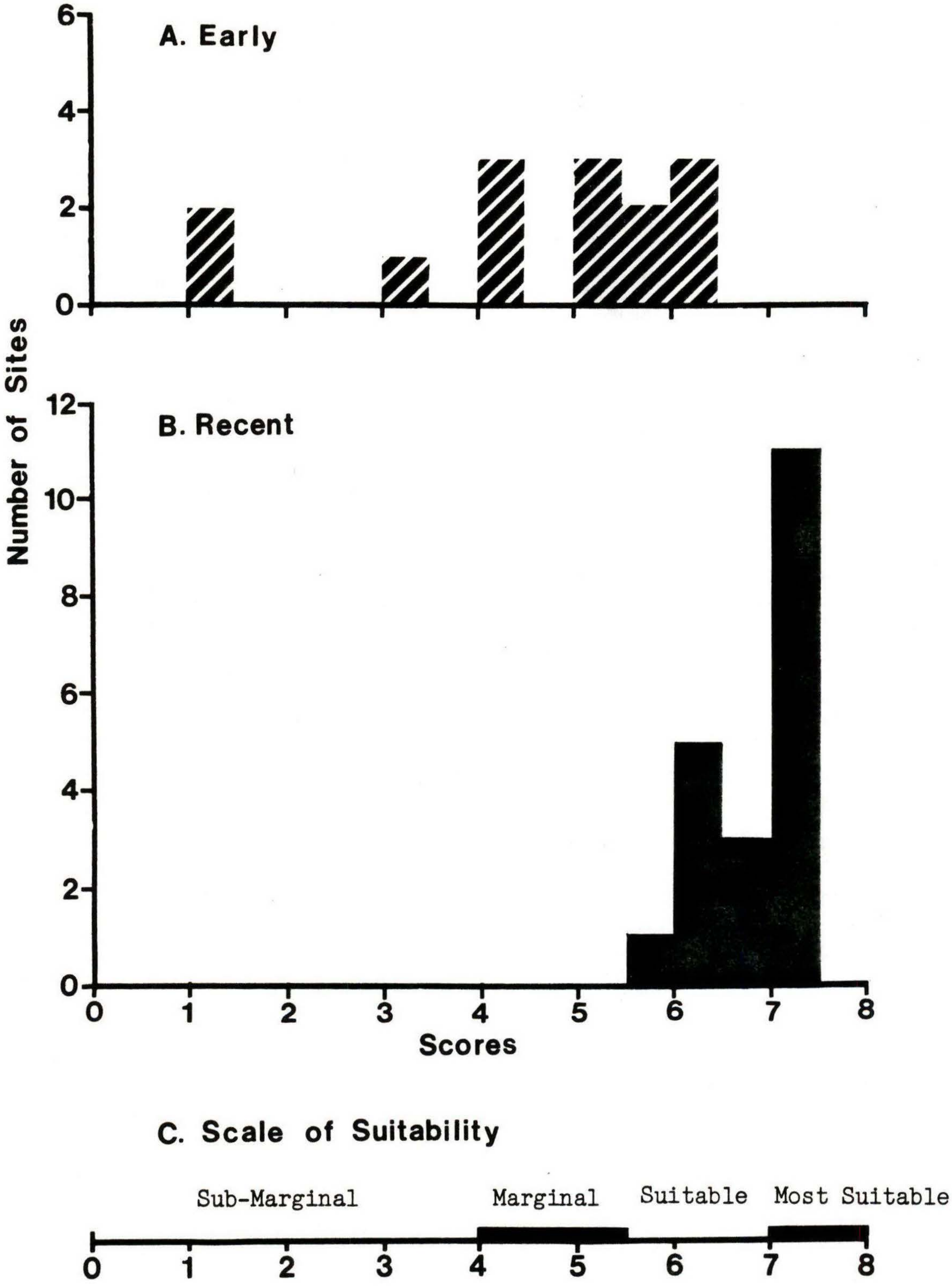


Figure 14. Site evaluation scores. For A, N=14. For B, N=20.

Surface Water		Cliff Height	Cliff Extent	Total Topographic Relief	Rank
Near Extensive Permanent	Provides prey concentration	Very Tall	Very Extensive	High	Most Suitable
				Moderate	Suitable
				Low	Marginal
			Extensive	High	Suitable
				Moderate	Suitable
				Low	Marginal
			Non-extensive	High	Suitable
				Moderate	Marginal
				Low	Marginal
		Tall	Very Extensive	High	Suitable
				Moderate	Marginal
				Low	Marginal
			Extensive	High	Suitable
				Moderate	Marginal
				Low	Sub-marginal
			Non-extensive	High	Marginal
				Moderate	Marginal
				Low	Sub-marginal
		Short			Sub-marginal
	Does not provide prey concentration	Very Tall	Very Extensive	High	Most suitable
				Moderate	Suitable
				Low	Marginal
			Extensive	High	Suitable
				Moderate	Suitable
				Low	Marginal
			Non-extensive	High	Suitable
				Moderate	Marginal
				Low	Marginal
		Tall	Very Extensive	High	Suitable
				Moderate	Marginal
				Low	Marginal
			Extensive	High	Suitable
				Moderate	Marginal
				Low	Unsuitable
			Non-extensive	High	Marginal
				Moderate	Marginal
				Low	Unsuitable
		Short			Unsuitable
Not Near Extensive Permanent		Very Tall	Very Extensive	High	Suitable
				Moderate	Suitable
				Low	Marginal
			Extensive	High	Suitable
				Moderate	Marginal
				Low	Marginal
			Non-extensive	High	Suitable
				Moderate	Marginal
				Low	Unsuitable
		Tall	Very Extensive	High	Suitable
				Moderate	Marginal
				Low	Unsuitable
			Extensive	High	Marginal
				Moderate	Marginal
				Low	Unsuitable
			Non-extensive	High	Marginal
				Moderate	Unsuitable
				Low	Unsuitable
		Short			Unsuitable

Figure 15. Habitat evaluation key.

predictability in locating breeding sites. Although cliffs in all suitability classes were checked for occupancy during the course of the study, all of 10 recently located eyries were in the suitable-most suitable category (as evaluated by an earlier version of the key).

SECTION III

BREEDING HABITAT EVALUATIONS

Methods

Potential sites were identified either during preliminary ground visits to historic eyries or, more important, during the aerial surveys. The aerial surveys were performed in two phases. In 1977 most of the Forest Service lands in Arizona were flown during a rapid two-day tour. On these flights potential habitat was broadly outlined on USGS topographic sheets (scale 1:250,000). In 1978 the forests were methodically flown using a Cessna 172 on seven days (65 hours flight time) over a one month period. During these flights the habitat evaluation key was used to sort lesser sites from those with good potential. In extremely rugged areas the Hubbard raised relief versions of the 1:250,000 USGS maps were used to more accurately identify important topographic features. After each flight the location data were reevaluated according to the parameters listed on the habitat evaluation key (Figure 15), and remapped on fresh 1:250,000 topo sheets. Most of the sites were subsequently visited on the ground for further evaluation and thereafter the sites were remapped in final form.

Ground visits were used to determine site occupancy and to further evaluate site suitability (i.e., to more closely estimate cliff height, cliff verticality, etc.). Several methods were used to determine occupancy. In 1975 many sites which were accessible from above were checked by flying a trained golden eagle (*Aquila chryaetos*) along the rimrock to attract defending falcons. One summering site was located by this means, but the technique proved unsatisfactory because of the difficulty of retrieving the eagle after being downed by defending raptors in rugged areas. Using an unusually aggressive and strong flying eagle this technique could prove even more useful. Occupancy was determined at restricted sites by spending 2-6 (usually 4-6) hours below and within one mile (preferrably within 0.5 mile) of the potential site sometime between 1 March and 15 July. Very long cliff lines were checked by a pair of observers hiking the area (preferrably from below) and periodically stopping for 1-2 hours below the most favorable cliffs. Meal times and campsites were chosen to allow longer inspection of key areas. By this means three eyries were found before breakfast and one during lunch. The locations of sites checked for occupancy on Forest Service lands are identified in Appendix I.

Results of the Survey

The results of the survey are mapped in Appendix II. Areas of known summer occupancy are mapped separately from potential sites. However,

potential sites, especially those designated as suitable and marginal, should be given high priority for falcon management. In mapping the sites a narrow buffer was included around the known and/or most likely areas of use. A narrow (mile wide) buffer was used for ease in identification of key areas eventhough some human activities could be deterimental as far as 5 miles from the site. Suggested buffers for various human activities, together with other management recommendations, are presented in Section V.

SECTION IV

WINTERING HABITAT

A literature and personal contact survey resulted in over 150 fall and winter records for the peregrine in Arizona. The reports are widely scattered, and no zones of concentration were identified on Forest Service lands.

In general, juveniles in fall are often observed far from likely breeding sites. Adults and young are regularly seen in winter in the broad valleys across the state. Records are to a degree concentrated about mesic areas, but this likely results from a concentration of watchers as well as falcons.

Considering what is known about the peregrine's habits elsewhere in North America, winter use on Forest Service lands in Arizona should be greatest at zones of prey abundance such as areas with concentrations of waterfowl and other migratory birds. River valleys, large reservoirs, etc. should be favored.

SECTION V

MANAGEMENT ALTERNATIVES

The management recommendations that follow are directed toward (1) minimizing disturbances to the falcons and their remaining habitat, (2) artificially increasing the number of wild falcons, and (3) improving breeding sites where practical. The Fish and Wildlife Service sponsored management plan for peregrine falcon populations in the Southwest (U.S. Fish and Wildlife Service 1977) provides general information on management and population recovery goals.

Enderson (1965) reported that the peregrine at temperate latitudes is "weakly or non-migratory." In Arizona some peregrines remain near the eyrie at least most of the year. Courtship is actively underway in early March and adults have been observed at the eyries in mid September. As a result of this very long period of occupancy, potentially disruptive activities which must occur near the eyries should be scheduled between 1 October and 15 January.

Minimizing Disturbances

Information management: The need for discretion in handling eyrie location information especially within governmental agencies was discussed in Section I. Judging by the happenings in other western states, agency competency in raptor management issues will, in large measure, be judged by how sensitive location information is handled. The location information in this report should be treated as confidential and should be filed for use on a site by site basis. Even when the need arises it should be given only to those who have a clear need from a management standpoint.

Law enforcement: Where breeding sites remain unknown there is no need to enforce the non-harrassment provision of the Endangered Species Act. However, in those instances where sites are intruded it may be advisable to establish a warden system. One drawback of this alternative is that the very act of enforcing non-harrassment leads to an increase in the number of persons knowning the breeding location.

Eyrie wardens should be considered a last alternative to be used only when other efforts to protect the privacy of the birds have failed. Jack H. Berryman, Acting Associate Director of the U.S. Fish and Wildlife Service, wrote (pers. comm. 23 February 1978): "This year, over $300,000 was spent in protecting falcon eyries." Considering the small number of eyries now protected and the number of eyries which would potentially need

protection if all locations were known, the cost would be prohibitive. Most sites in Arizona are so isolated that logistical considerations would make the task of protecting them nearly impossible. If site locations remain unknown there is little need to engage in expensive enforcement activities.

More difficult to control is the illegal shooting of peregrine falcons. Unfortunately, the birds tend to concentrate in winter near waterfowl hunting areas where they can readily be shot by irresponsible gunners. This is, at least locally, an important factor for the peregrine (Enderson 1969, Herren 1969, Lindberg 1975 in U.S. Fish and Wildlife Service 1977, Snyder and Snyder 1975, and Shor 1976), and illegal shooting has been identified as an important raptor decimating factor for other species as well (Ellis et. al. 1969 and White 1974).

Limiting incidental human use: Limiting access to areas heavily used by the falcons will minimize the potential for disturbance from casual human intrusion. Hiking and camping activities can be completely compatable with falcon occupancy if a narrow buffer zone is allowed. Broader buffers are needed for greater disturbances such as rock climbing and off-road-vehicle use. Where falcons are nesting in very close proximity to humans, there is no need to eliminate trails, picnic grounds, etc. except where conflicts exist (i.e., where the birds are disturbed by the human activities). However, further development of such facilities should be discouraged within the proposed buffer zones (Table 3).

The buffer zone widths, although chosen somewhat arbitrarily for some activities, are derived from observations of the responses of Arizona peregrines to various disturbances near the eyrie. In Arizona, as in New England (Herbert and Herbert 1969), the falcons appear more sensitive to disturbances above the eyries than below: hence the wider buffer zones for some activities above the breeding cliff. Louder activities and those involving more people should be given wider buffer zones.

Little is known of the effect of low flying aircraft on breeding falcons. During the aerial surveys no falcons were flushed or observed although the aircraft often passed within .3 miles of cliffs which later proved occupied. At one site in Arizona I observed a helicopter pass within 120 yards of the eyrie (at eyrie level). Neither adult flew or protested. Nevertheless, it is probably wise to route air traffic away from breeding and important wintering sites.

Surface management: Near breeding and wintering sites, land use practices should consider the falcon. Some of the most obvious potential disturbances are: grazing, logging, development of roads, controlled burns, fire control measures, and mining. Suitable buffer zones for activities not listed in Table 3 can be extrapolated from those activities listed. It is advisable to schedule extremely disruptive activities (e.g., blasting and heavy equipment operations outside but near the buffer zones) during

TABLE 3

PROPOSED BUFFER ZONES AROUND PEREGRINE FALCON USE SITES[1]

Activity[1]	Width of Buffer Zones Above Cliff	Width of Buffer Zones Below Cliff
Hiking	½ mile	¼ mile
Camping	½ mile	¼ mile
Rock climbing	3/4 mile	½ mile
Trail clearing	½ mile	½ mile
Aircraft flight lane (low altitude)	1 mile	1 mile
Off-road-vehicle use	1 mile	1 mile
Logging	1 mile	1 mile
Road construction	1 mile	1 mile
Fire control measures	1 mile	1 mile
Controlled burning	1 mile	2 miles
Mining (heavy equipment and/or blasting)	3 miles	3 miles
Building construction	2 miles	2 miles

[1]Buffers should be in effect from 15 January-1 October for temporary disturbances. Activities which result in long term habitat alterations (logging, road construction, surface mining, etc.) should be avoided year around.

the period of reduced occupancy (October 1 - January 15).

Pesticide applications: Pesticide and herbicide application practices should in all cases consider the falcon. The close association between reproduction failure of raptorial birds and dietary contamination by some of the chlorinated hydrocarbon pesticides has been clearly documented (see review in Peakall 1975). With this evidence it seems most unwise for any agency to pursue a falcon management program while continuing to distribute suspect chemicals.

Productivity Enhancement Measures

In addition to providing for a clean environment, three general means are available for increasing productivity. First, the number of birds in the wild can be increased by various reintroduction methods (Temple 1978). Second, food supplies can be enhanced. Third, the number of suitable breeding sites can be increased by providing otherwise prime sites with suitable perching, breeding, and roosting ledges. The recovery plan (U.S. Fish and Wildlife Service 1977) outlines the possible methods for manipulating productivity (e.g., double-clutching, artificial incubation, introducing captive produced nestlings to foster parents of other or the same species). These labor intensive activities (Cade 1978) may not be necessary in Arizona because of the relatively large number of pairs still present.

The second enhancement measure, altering food supplies, has been largely unattempted. One possibility at some Forest Service sites in Arizona is to provide an abundant, pesticide free, food supply (e.g., pigeon lofts) near eyries where pairs have repeatedly failed to reproduce. For other sites, where topographic factors appear very suitable, but birds are not now found, it will occasionally be possible to encourage waterfowl use of a lake or marsh and thereby provide food for the peregrine.

The third measure dealt with altering potential breeding sites to make them more suitable for occupancy. For example, controlled burning or selective logging may be used to favor a certain seral plant community, or blasting may be used to create breeding ledges on otherwise suitable cliffs.

In planning cliff enhancement activities it is important to understand the preferences of the falcon. Data were gathered at Arizona eyries where the exact breeding sites are known. Several sites were climbed and measurements were taken directly. At other sites sizes were approximated from nearby vantage points.

Factor 1. Relative height and elevation of the breeding cliff. At those sites where a choice was available, most falcons nested on the tallest and most elevated cliffs (of comparable height). For 28 sites, 22 (79%) were on the tallest available cliff. For 29 sites, 21(72%) were on the most elevated cliff of comparable height.

Factor 2. Height on the breeding cliff. For 14 cliffs where the exact eyrie site is known, the eyrie height averaged 66.4% of the total height of the cliff (Figure 16). The range in this ratio (height of eyrie/ total height of cliff = ratio) was from .29 to .83. At the single eyrie which was below 50% of the total cliff height, the eyrie was still 200 feet from the cliff base. An acceptable height range for artificial eyries is 60-80% of the total cliff height. Rarely should an artificial eyrie be lower than 200 feet from the cliff base.

Factor 3. Directional orientation of the eyrie. Cliff orientations were discussed earlier (Section II). Directional orientation of the ledge is presented in Figure 17. There are no clear directional preferences, but in creating ledges it is advisable to avoid south and west facing situations unless the overhang is sufficient to provide shade during the heat of the day.

Factor 4. Eyrie structures. Prairie falcons (Falco mexicanus) tend to use rather crowded breeding sites. Peregrines generally use much larger structures, but there is some overlap in site use if not preference. Of 14 recent peregrine eyries, only 2 are in potholes (Table 4). Four are in spacious caves (about as high at the lip as long), seven are on overhung ledges (much longer than high at the lip), and the final site, somewhat between a cave and an overhung ledge, is included in Table 4 as an overhung ledge. These three structural types are roughly separable in the field by the amount of whitewash (droppings from the young) visible along the eyrie lip after the young fledge. Potholes have a conspicuous flag all along the lip. Long overhung ledges, unless very broad, show a scattering of whitewash streaks but no conspicuous flag. Cave eyries (which are really very large potholes) tend to show little or no whitewash along the eyrie lip.

Table 4 provides a range of sizes for known eyries. However, at some sites there are few choices available, so the ledges used were perhaps chosen from necessity. Of 8 sites where many alternatives were available, caves and overhung ledges were used 4 times each.

The distance between the eyrie floor (at the scrape: the location where the eggs are placed) and the roof was relatively constant. For one eyrie (Pothole No. 1 in Table 4) there was no low roofed area in the eyrie structure. At six eyries where there was a sloping roof and where the birds resultantly could adjust the scrape-roof distances, this parameter varied between 1.3 and 2.5 feet.

Factor 5. Eyrie substrate. The composition of the litter in the scrape varied from site to site. At repeatedly used sites, bone fragments, egg shell fragments, and droppings were readily detectable. The scrape material in general consisted of gravel, sand and silt. One early eyrie was an abandoned stick nest (probably that of a red-tailed hawk, Buteo jamaicensis), and at one recent site the remains of a stick nest protruded through a thick layer of silt. Interestingly, 8 of 10 recent eyries were

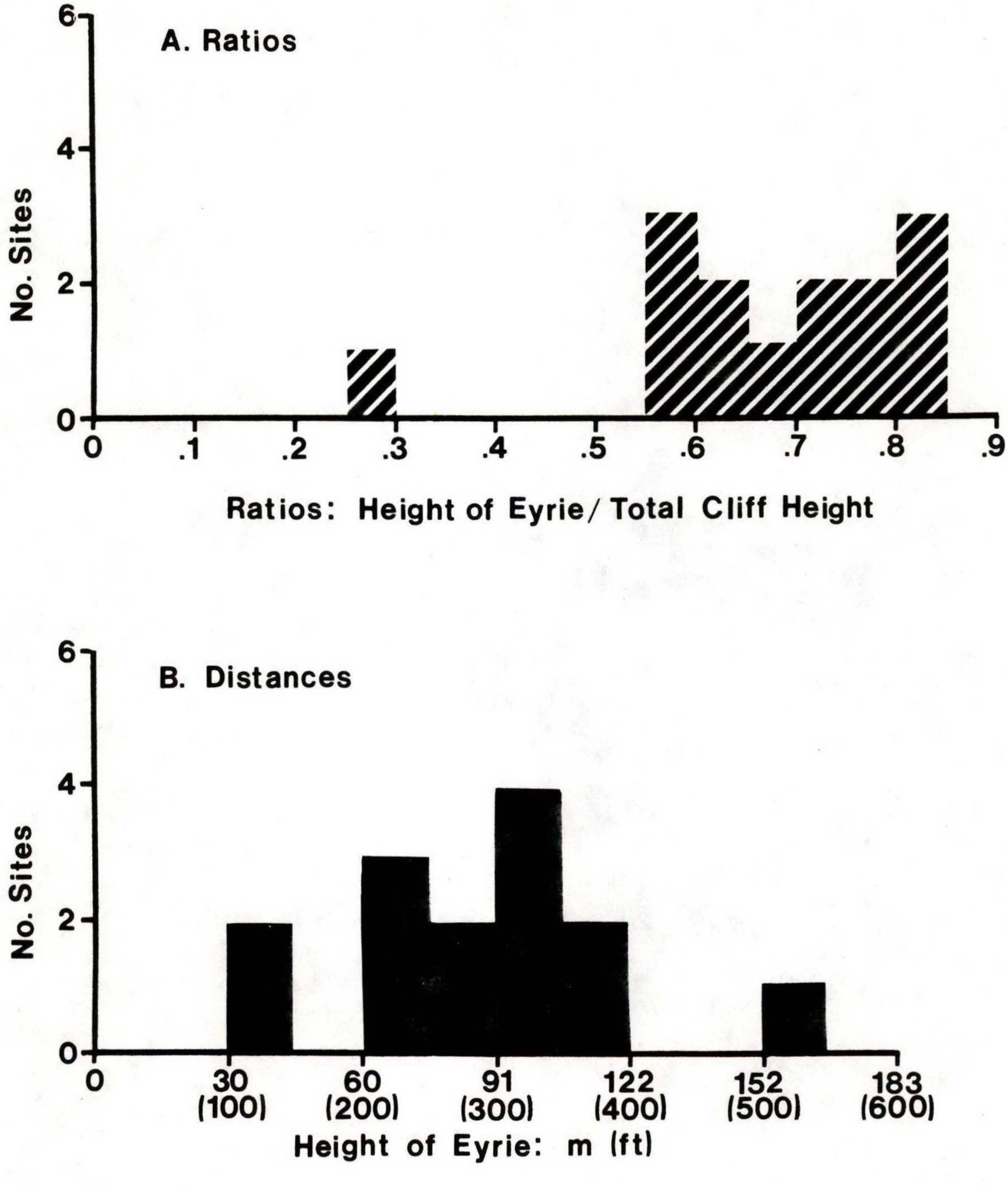


Figure 16. Height of eyrie on cliff (N=14).

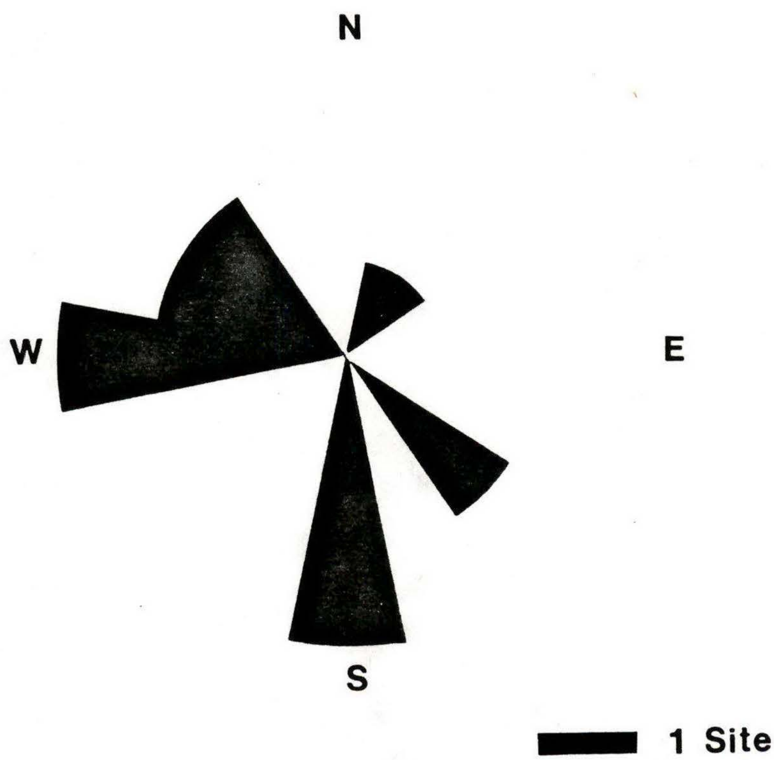


Figure 17. Directional exposure of eyrie ledges (N=14).

TABLE 4

DESCRIPTION OF PEREGRINE FALCON BREEDING LEDGES[1,2,3]

Structural Type	No.	Size at Mouth Length	Size at Mouth Height	Breadth (Lip to Wall)	Height[4] (at scrape center)	Distance to Lip[4] (from scrape center)	No. Alternate Ledges Available
Cave	1	ca 6	?	?	?	?	Few
	2	10.5	12	12.8[5]	2.5	6.3	Few
	3	ca 15	?	?	?	?	Many
	4	ca 20	?	?	?	?	Many
Pothole	1	4	5.1	3.2	4.5	1.3	Few
	2	2.9	1.3	2.1	1.5	?	Few
Overhung Ledge	1	ca 15	ca 2.5	?	?	ca 1.5	Many
	2	ca 12	?	?	?	?	Many
	3	ca 7.5	ca 2	?	ca 1.3	?	Few
	4	ca 25	ca 4	ca 5	?	?	Many
	5	ca 8	ca 1.5	ca 4	ca 1.5	?	Many
	6	13	3.1	3.5	1.5	2.4	Few
	7	38	6.3	6	1.7	2.4	Many
	8	ca 15	ca 8	?	?	?	Many

1Measurements in feet.
2Eyrie floor measurements are for the area readily available to large nestlings.
3Values preceeded by "ca" in table are from photographic comparisons with measured cliff segments and/or comparisons with sizes of birds and vegetation at the eyrie.
4The scrape location was determined by the presence of eggshell fragments and/or the proximity of a concentrated whitewash ring from small nestlings.
5Includes narrow tunnel ca 5 feet long.

strewn with cobble stones and boulders. Although not essential eyrie components, sizeable rocks can provide shade and additional protection from avian predators.

Summary of eyrie location parameters. In locating and constructing artificial ledges it seems adviseable to closely simulate the most suitable natural sites. The ideal site should have the following features:

1. The eyrie cliff should be the tallest and most elevated suitable cliff in the area.
2. The eyrie ledge should be at least 200 feet from the cliff base and should be placed at 60-80% of the cliff height.
3. The eyrie should not face between south and west.
4. The eyrie should be at least 10-15 feet long with an overhung roof sloping gradually to a wall 4-6 feet from the lip.
5. In the zone where the roof is 2.5-1.0 feet from the floor, a mixture of fine gravel, sand and silt should extend 2-4 inches deep.
6. A scattering of rocks 2-12 inches in diameter and concentrated along the rim will complete the site.

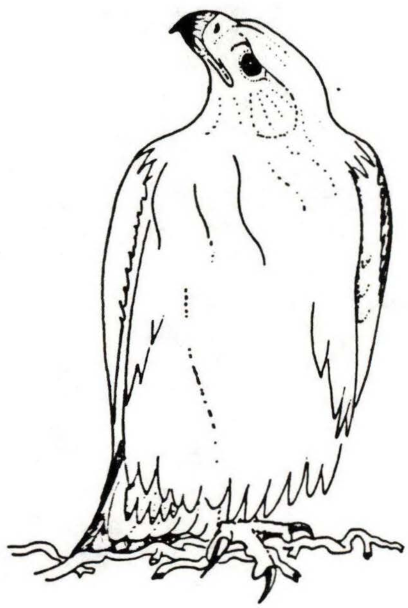
SECTION VI

SUMMARY

The peregrine falcon remains in significant numbers in Arizona. This report provides information on management areas and management practices which can contribute to the bird's survival.

In informing the management biologist of the habitat preferences of the falcon, many site description factors were examined. Those traits which appeared common to most or all Arizona sites (and therefore most useful in evaluating habitat) were: elevation; cliff height, verticality, and extent; topographic relief; and availability of water (surface and precipitation). These parameters were collated into a habitat evaluation key which in aerial and ground surveys were used to evaluate all Forest Service lands in Arizona.

Many management alternatives are available. Those discussed herein involve habitat preservation, controlling disruptive human activities, and enhancing productivity. Given their privacy (and an increasingly pesticide free environment) the peregrine falcon will likely exist indefinitely on Forest Service lands in Arizona.



SECTION VII

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